Introduction

to the

High Level Architecture

M&S Critical to DoD's Ability to Meet its Mission
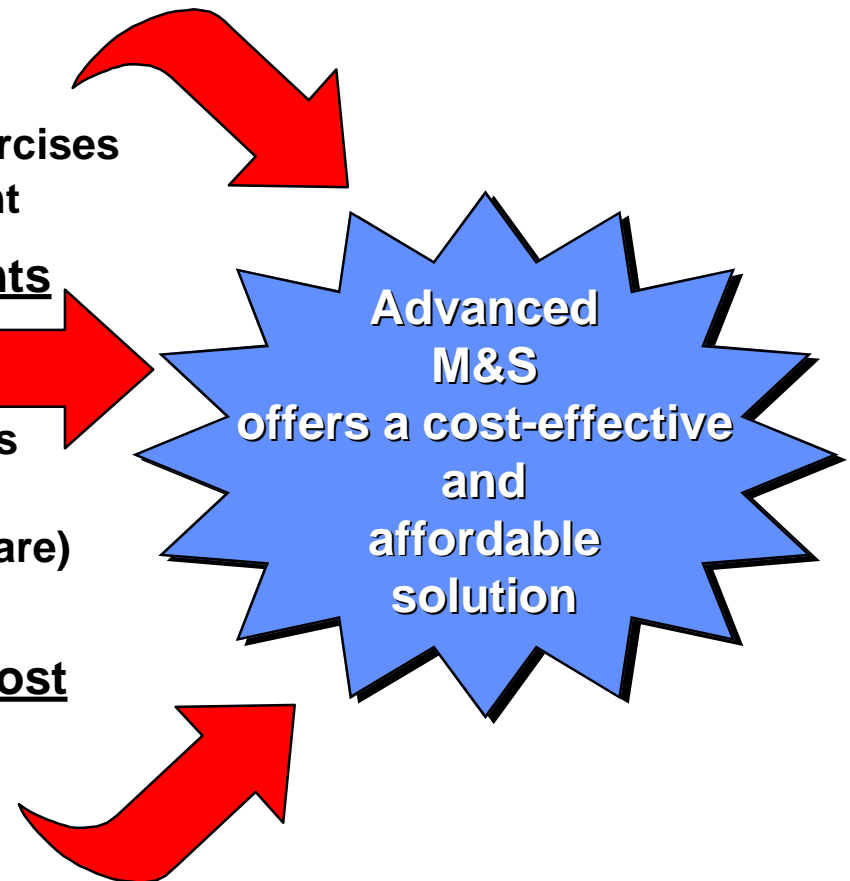
Continuing squeeze on DoD resources
- shrinking, dispersed force structure
- competition for O&M funds limits field exercises
- need to carefully examine every investment

More demanding operational requirements
- new, more complex missions
- vastly expanding mission space
- increased complexity of systems and plans
- increasing demand for joint training
- security challenges (e.g., information warfare)
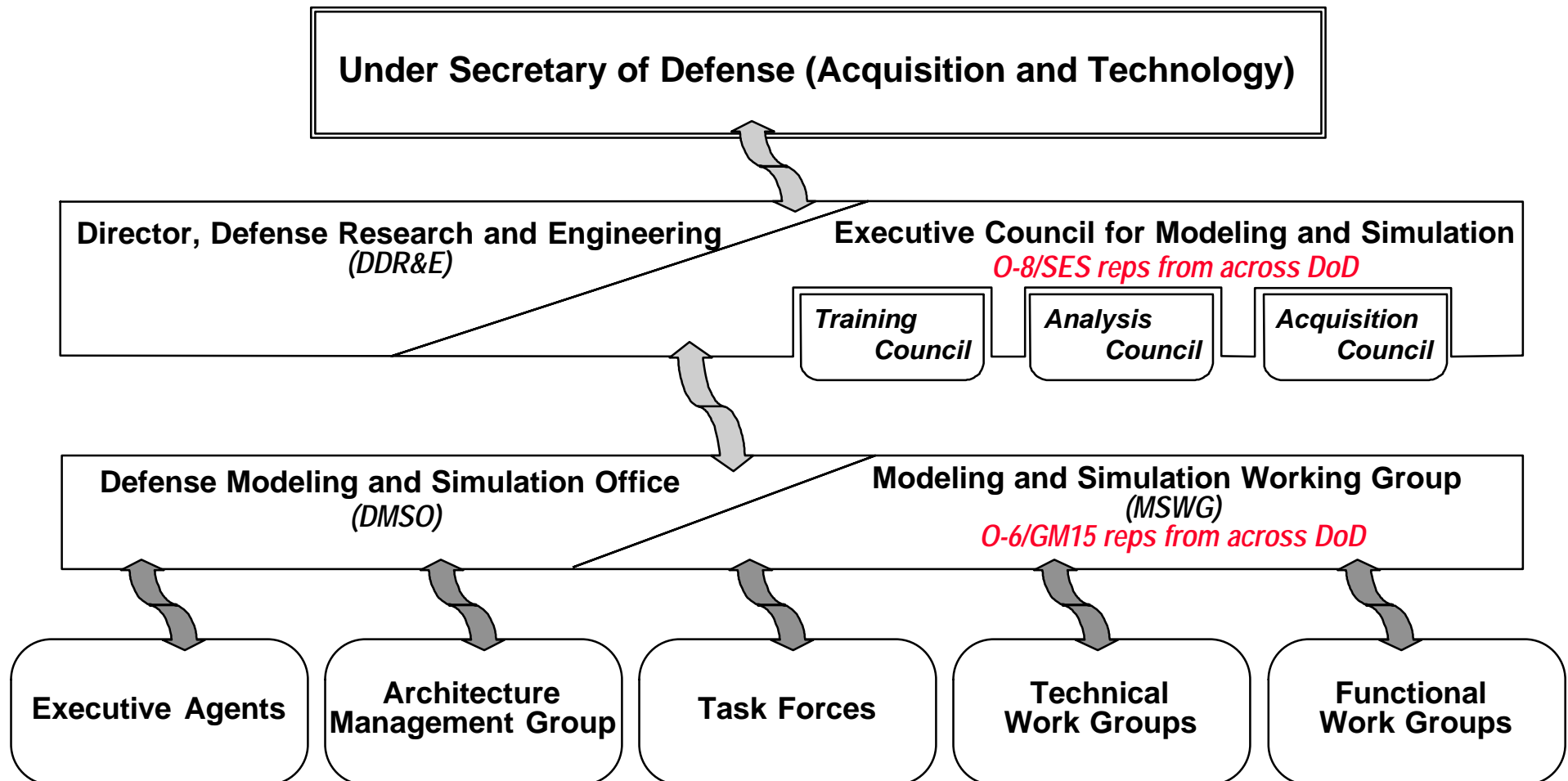- no traditional way to address

Much more technical capability at less cost
- communications
- computers
- advanced software technology
- displays/human-machine interfaces
- data storage and management

Advanced M&S offers a cost-effective and affordable solution

DoD M&S Management Structure

Under Secretary of Defense (Acquisition and Technology)

Director, Defense Research and Engineering
(DDR&E)

Executive Council for Modeling and Simulation
O-8/SES reps from across DoD

Training Council	Analysis Council	Acquisition Council

Defense Modeling and Simulation Office
(DMSO)

Modeling and Simulation Working Group
(MSWG)
O-6/GM15 reps from across DoD

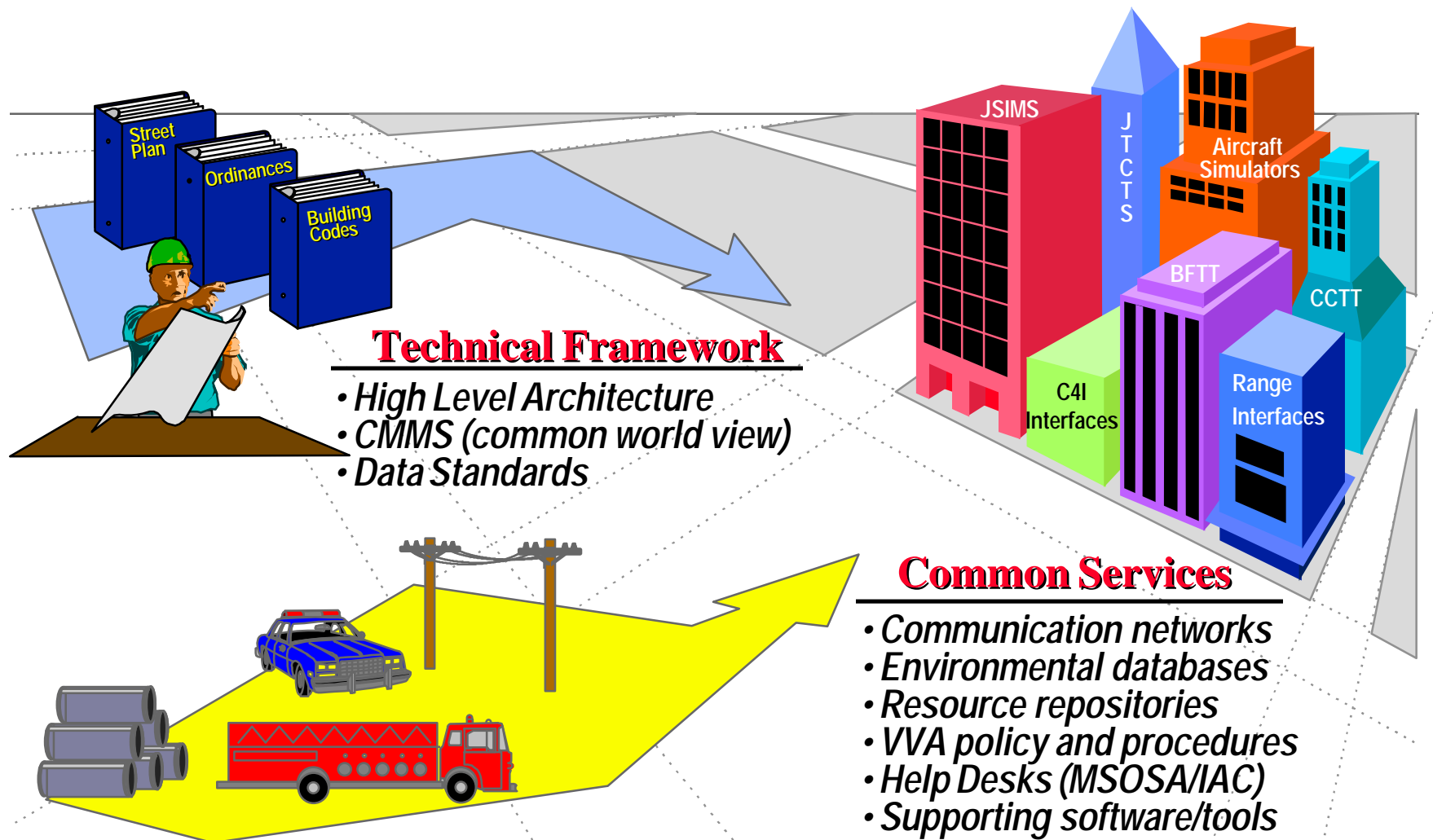| Executive Agents	Architecture Management Group	Task Forces	Technical Work Groups	Functional Work Groups

Why HLA Now?

- **DoD M&S Vision**

  - " ...common use of these environments will promote a closer interaction between the operations and acquisition communities in carrying out their respective responsibilities. To allow maximum utility and flexibility, these modeling and simulation environments will be constructed from affordable, reusable components interoperating through an open systems architecture."

- **DoD embarking on development of new generation of simulations**

- **Current technology does not provide tools necessary to achieve DoD M&S Vision (i.e., ALSP and DIS)**
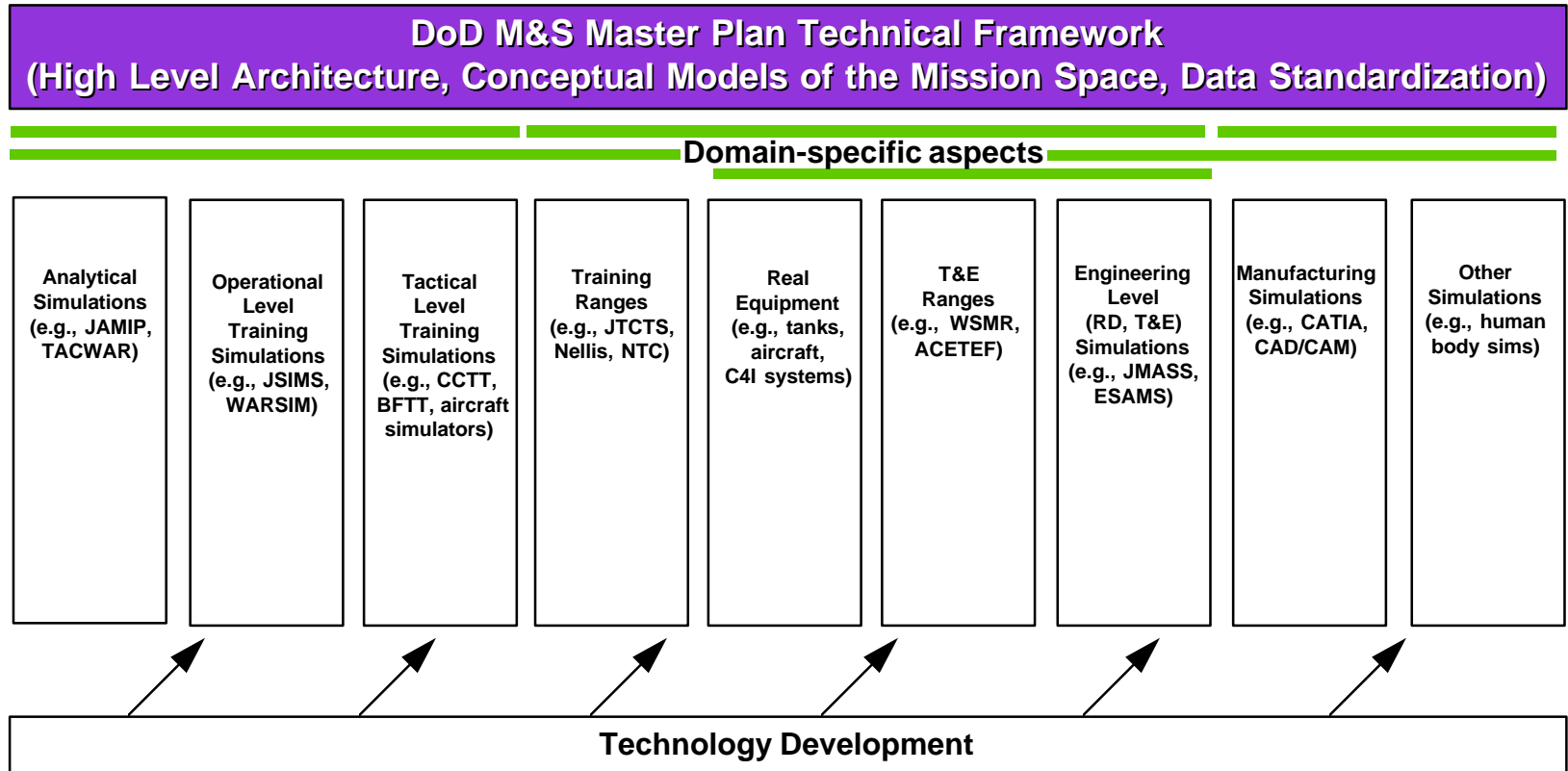
DoD M&S Strategy:
An Analogy to City Planning

Technical Framework

- *High Level Architecture*
- *CMMS (common world view)*
- *Data Standards*

Street Plan

Ordinances

Building Codes

JSIMS

JTCTS

Aircraft Simulators

BFTT

CCTT

C4I Interfaces

Range Interfaces

Common Services

- *Communication networks*
- *Environmental databases*
- *Resource repositories*
- *VVA policy and procedures*
- *Help Desks (MSOSA/IAC)*
- *Supporting software/tools*

Payoffs: Interoperability and reuse = capability and cost-effectiveness

An Overarching Technical Framework

**DoD M&S Master Plan Technical Framework
(High Level Architecture, Conceptual Models of the Mission Space, Data Standardization)**

Domain-specific aspects

| Analytical Simulations (e.g., JAMIP, TACWAR) | Operational Level Training Simulations (e.g., JSIMS, WARSIM) | Tactical Level Training Simulations (e.g., CCTT, BFTT, aircraft simulators) | Training Ranges (e.g., JTCTS, Nellis, NTC) | Real Equipment (e.g., tanks, aircraft, C4I systems) | T&E Ranges (e.g., WSMR, ACETEF) | Engineering Level (RD, T&E) Simulations (e.g., JMASS, ESAMS) | Manufacturing Simulations (e.g., CATIA, CAD/CAM) | Other Simulations (e.g., human body sims) |

Technology Development

Payoffs: Interoperability and reuse = capability and cost-effectiveness

DoD M&S Master Plan

Objective 1	Objective 2	Objective 3	Objective 4	Objective 5	Objective 6
Develop a common technical framework for M&S	Provide timely and authoritative representations of the natural environment	Provide authoritative representations of systems	Provide authoritative representations of human behavior	Establish a M&S infrastructure to meet developer and end-user needs	Share the benefits of M&S

Sub-objectives	*Sub-objectives*		*Sub-objectives*	*Sub-objectives*	*Sub-objectives*
1-1 High-level architecture	**2-1** Terrain		**4-1** Individuals	**5-1** Field systems	**6-1** Quantify impact
1-2 Conceptual models of the mission space	**2-2** Oceans		**4-2** Groups and organizations	**5-2** VV&A	**6-2** Education
1-3 Data standardization	**2-3** Atmosphere			**5-3** Repositories	**6-3** Dual-use
	2-4 Space			**5-4** Communications	
				5-5 Coordination Center	

signed out by USD (A&T) on 17 October 1995

DoD M&S Master Plan
Objective 1-1

Objective 1-1

- **Establish a common high-level simulation architecture to facilitate the interoperability of all types of models and simulations among themselves and with C4I systems, as well as to facilitate the reuse of M&S components**

  - **Simulations developed for particular DoD Components or Functional Areas must conform to the High Level Architecture**

  - **Further definition and detailed implementation of specific simulation system architectures remain the responsibility of the developing Component**

> **The Common Technical Framework, and specifically the High Level Architecture, represents the highest priority effort within the DoD modeling and simulation community**

How Did We Get Here?

Technical

Limited scope simulations, little interoperability prior to 1988

DSB: Computer Applications to Training & Wargaming

SIMNET

DIS Standards begun

ALSP- linking of Service wargames

HLA begun

HLA Baseline approved

88	89	90	91	92	93	94	95	96

DEPSECDEF Memo
• EXCIMS and DMSO established

DoDD 5000.59

Service M&S Offices established

M&S Master Plan

Executive Agents

Architecture Management Group

EXCIMS Functional Area Councils
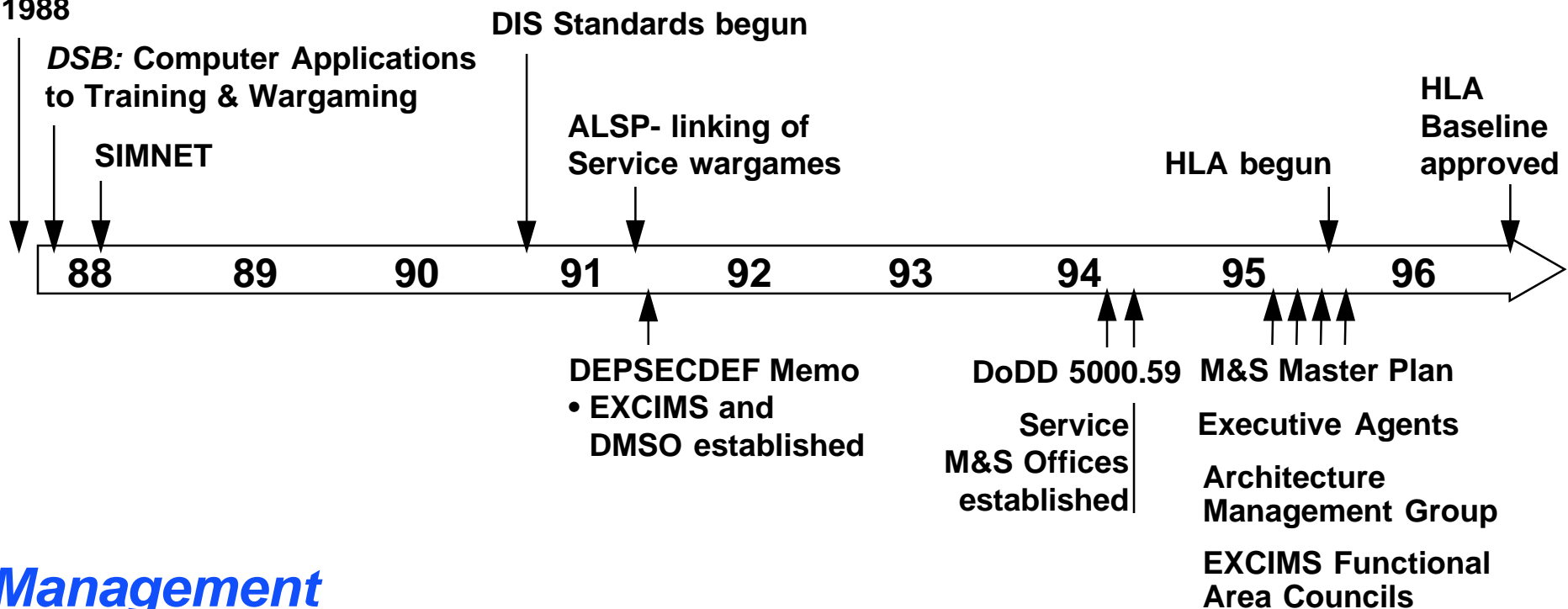
Management

No formal management structure	Management structure stand-up	Management structure in place

What is the
High Level Architecture?

- **Major functional elements, interfaces, and design rules, pertaining to all DoD simulation applications, and providing a common framework within which specific system architectures can be defined**

DoD Policy:

" Under the authority of [DoD Directive 5000.59], and as prescribed by [the DoD Modeling and Simulation Master Plan], I designate the High Level Architecture as the standard technical architecture for all DoD simulations."

**Dr. Paul Kaminski
10 September 1996**

HLA Compliance Milestones

- **"No Can" Dates**
  - "No Can Pay"- first day of FY99
    - No funds toward developing/modifying non-HLA simulations
  - "No Can Play"- first day of FY01
    - Retirement of non-HLA compliant simulations

- **Components will review simulation projects/programs for HLA compliance by end of 2d Qtr FY97**
  - Results reported to and tracked by DMSO

- **Supersedes current interoperability standards (DIS, ALSP)**

- **Waivers to HLA policy require USD(A&T) approval**

Scope of HLA

- **Applicable to broad range of functional areas (e.g., training, contingency planning, analysis, and acquisition)**

- **Applicable to simulations involving pure software representations, man-in-the-loop simulators, and interfaces to live components (e.g., instrumented-weapon systems and C3 systems)**

Role of HLA

- **Used by simulation system developers and policy makers**

- **Provides systematic and consistent basis for addressing simulation system design and implementation issues**
  - **Many difficult issues still need to be resolved at system level – e.g., mechanisms for scalability, aggregation-disaggregation**

- **Facilitates interoperability and reuse through a set of commonly applicable rules**

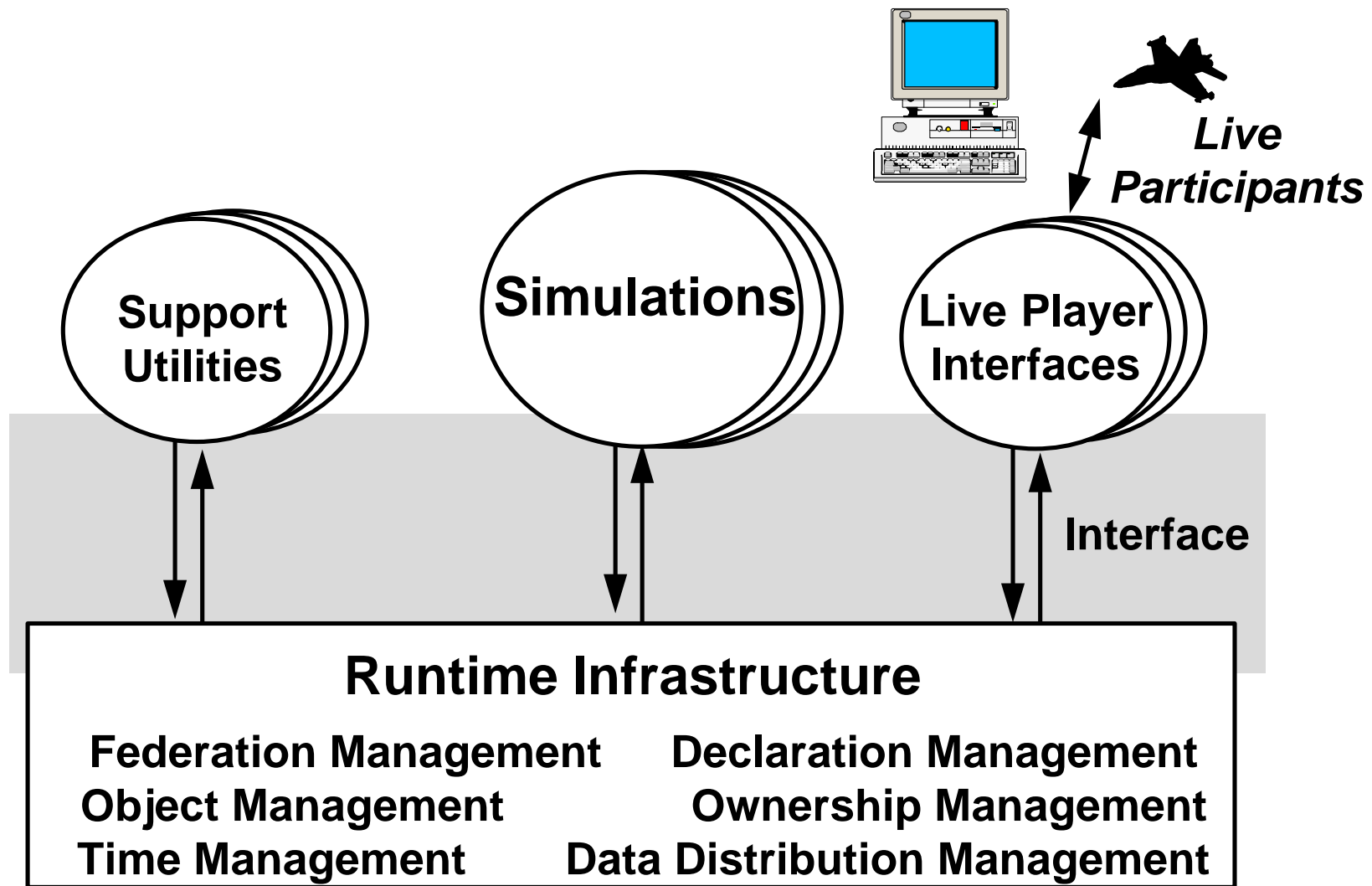- **Furnishes framework for making policy decisions (e.g., imposition of specific standards)**

Rationale for HLA Design

- **Basic premises:**

  - No single, monolithic simulation can satisfy the needs of all users

  - All uses of simulations and useful ways of combining them cannot be anticipated in advance

  - Future technological capabilities and a variety of operating configurations must be accommodated

- *Consequence:* Need <u>composable</u> approach to constructing simulation federations

- *Resulting design principles:*

  - Federations of simulations constructed from modular components with well-defined functionality and interfaces

  - Specific simulation functionality separated from general purpose supporting runtime infrastructure

Functional View of the Architecture

Support Utilities

Simulations

Live Player Interfaces

Live Participants

Interface

Runtime Infrastructure

Federation Management   Declaration Management

Object Management   Ownership Management

Time Management   Data Distribution Management

Defining the HLA

- **The HLA is comprised of three elements:**

  - **HLA Rules**

    - **A set of rules which must be followed to achieve proper interaction of simulations in a federation. These describe the responsibilities of simulations and of the runtime infrastructure in HLA federations**

  - **Interface Specification**

    - **Definition of the interface functions between the runtime infrastructure and the simulations subject to the HLA**

  - **Object Model Template**

    - **The prescribed common method for recording the information contained in the required HLA Object Model for each federation and simulation**

HLA Object Models

- **Object models describe:**

  - The set of shared objects chosen to represent the real world for a planned simulation or a federation

  - The attributes and interactions of these objects

  - The level of detail at which these objects represent the real world, including spatial and temporal resolution

  - The key models and algorithms used in representing the objects

- **The HLA will provide a template to characterize the object models**

  - **Object Model Template (OMT) specification**

  Note: The term object model here should not be identified with the term used in some texts on object-oriented analysis and design methodologies. The term is used more generally here.

HLA Object Models and OMT

- **Federation Object Model (FOM)**

  - **A description of all shared information (objects, attributes, associations, and interactions) essential to a particular federation**

- **Simulation Object Model (SOM)**

  - **Describes objects, attributes and interactions in a particular simulation which *can* be used externally in a federation**

- **Object Model Template (OMT)**

  - **Provides a common framework for HLA object model documentation**
  - **Fosters interoperability and reuse of simulations via the specification of a common representational framework**

HLA Interface Specification

Category	Functionality
Federation Management	Create and delete federation executions
	Join and resign federation executions
	Control checkpoint, pause, resume, restart
Declaration Management	Establish intent to publish and subscribe to object attributes and interactions
Object Management	Create and delete object instances
	Control attribute and interaction publication
	Create and delete object reflections
Ownership Management	Transfer ownership of object attributes
Time Management	Coordinate the advance of logical time and its relationship to real time
Data Distribution Management	Supports efficient routing of data

HLA RTI Services over the Life of a Federation

Startup   **Operations**   **Shutdown**

Ownership Management
Time Management
Data Distribution Management
Object Management
Declaration Management
Federation Management

Time →
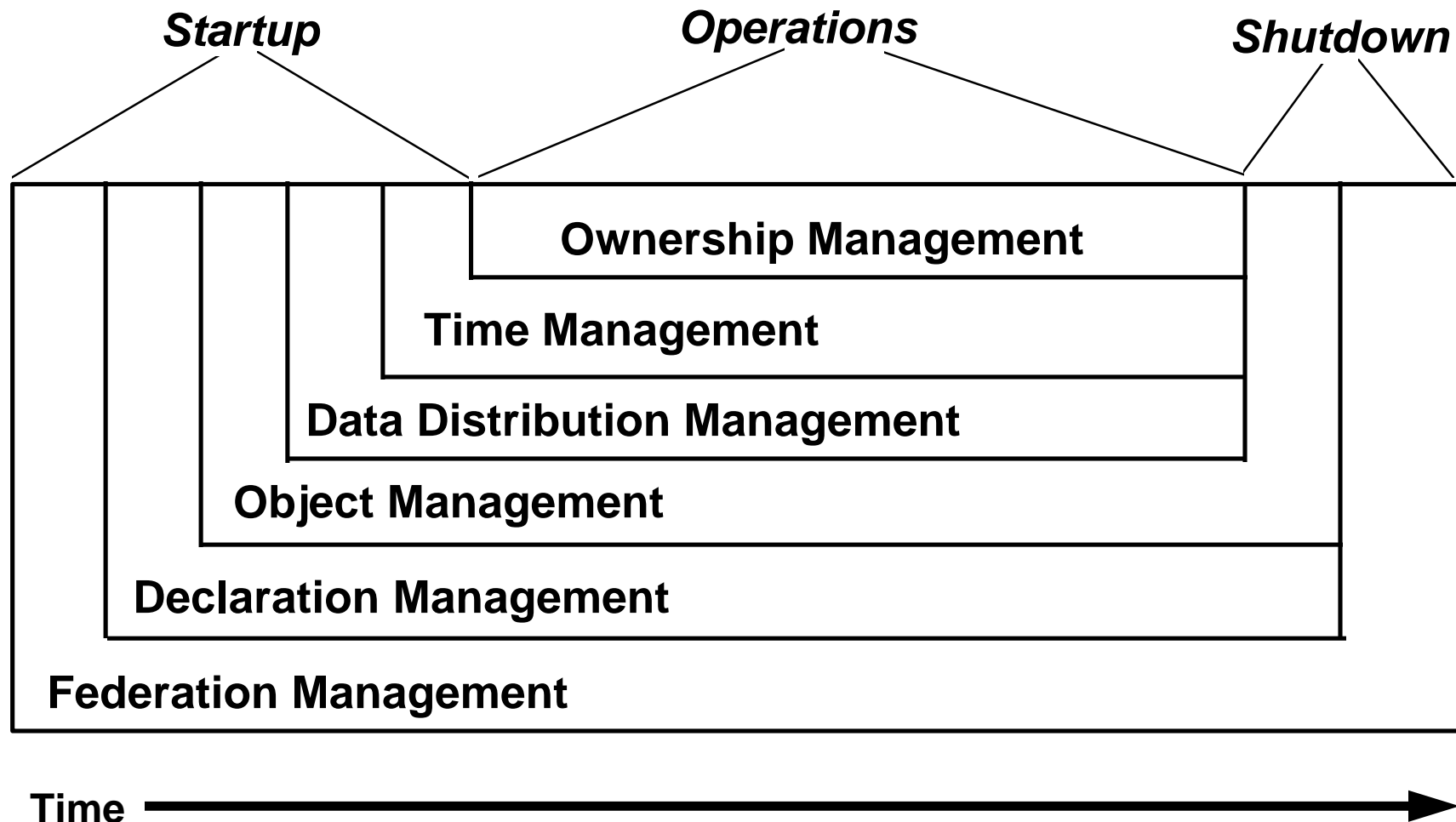
Federation Rules

1   Federations shall have an HLA Federation Object Model (FOM), documented in accordance with the HLA Object Model Template (OMT).

2   In a federation, all representation of objects in the FOM shall be in the federates, not in the runtime infrastructure (RTI).

3   During a federation execution, all exchange of FOM data among federates shall occur via the RTI.

4   During a federation execution, federates shall interact with the runtime infrastructure (RTI) in accordance with the HLA interface specification.

5   During a federation execution, an attribute of an instance of an object shall be owned by only one federate at any given time.

Federate Rules

6   Federates shall have an HLA Simulation Object Model (SOM), documented in accordance with the HLA Object Model Template (OMT).

7   Federates shall be able to update and/or reflect any attributes of objects in their SOM and send and/or receive SOM object interactions externally, as specified in their SOM.

8   Federates shall be able to transfer and/or accept ownership of attributes dynamically during a federation execution, as specified in their SOM.

9   Federates shall be able to vary the conditions (e.g., thresholds) under which they provide updates of attributes of objects, as specified in their SOM.

10 Federates shall be able to manage local time in a way which will allow them to coordinate data exchange with other members of a federation.

HLA Supporting Software

- **HLA is an architecture, <u>not</u> software -- however, to facilitate cost-effective implementation of HLA, DMSO is developing an initial suite of HLA supporting software**
  - **Openly distributed in the public domain**
  - **Open access to specifications (e.g., HLA IF Spec, OMT data interchange format) to foster development of commercial software to support HLA**

- **HLA On-line**
  - **Open mailing list for updates on HLA and information on HLA supporting software**
  - **To subscribe, send a message to listproc@msis.dmso.mil and have the body of the message say:**
    - **subscribe hla_online <firstname> <lastname>**

- **Address questions to hla@dmso.mil**

Runtime Infrastructure (RTI) Software

- **Runtime Infrastructure (RTI) software is available now**

- **Order from DMSO homepage (http://hla.dmso.mil)**
  - **Fill out form and submit**
  - **You will get confirmation by return e-mail with FTP address and password for download**
  - **Once registered you will be automatically notified of new releases**

- **Release includes**
  - **RTI SW**
  - **Installation guide and software**
  - **User documentation**
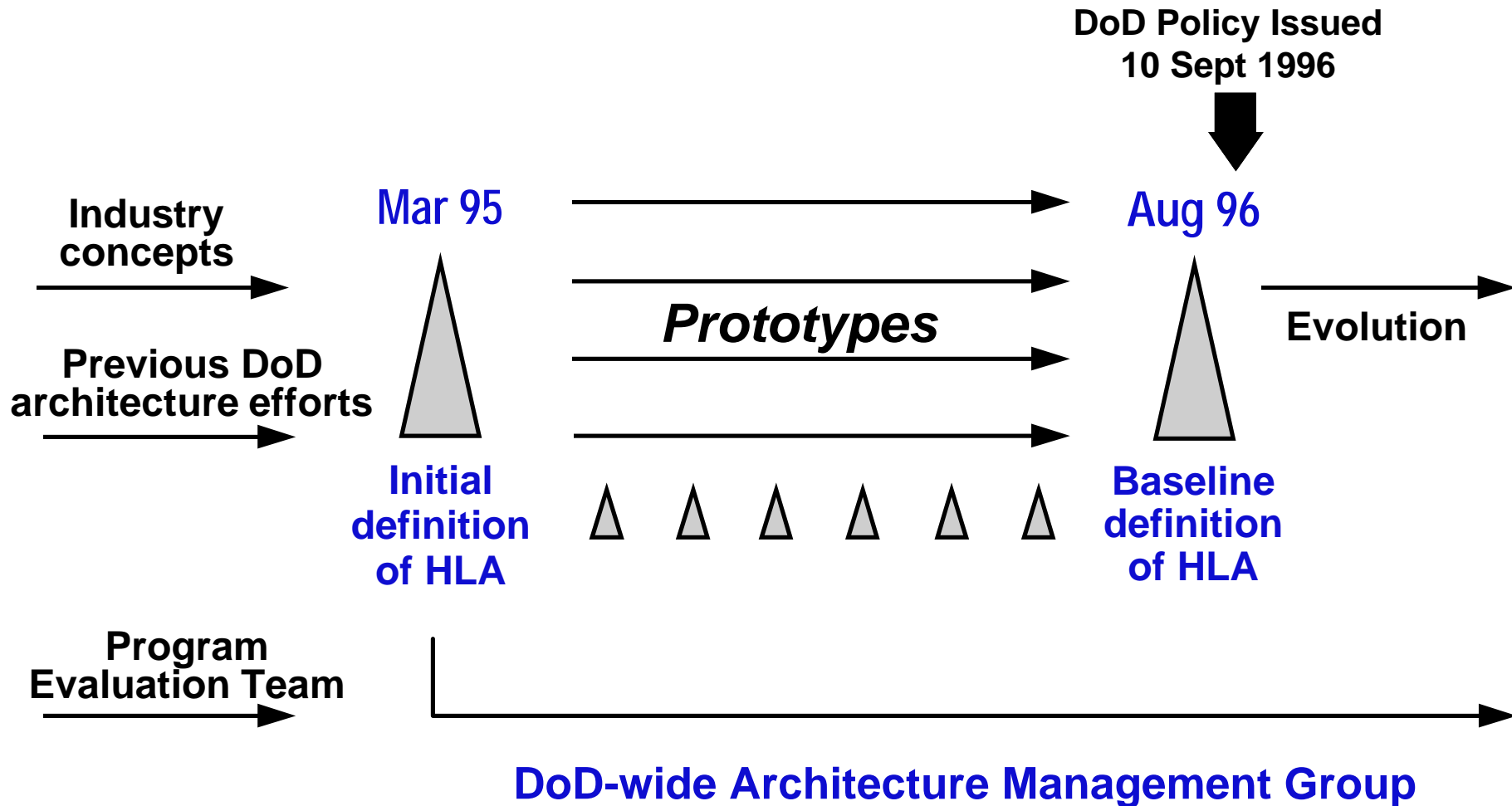 - **Test federate**
  - **Sample applications**

Object Model Development Tools

- **An object model toolset is in development**
  - **Support development and reuse of object models for cost-effective HLA federation development**
  - **Based on HLA tool architecture, and supported by open data interchange formats (DIFs)**

- **Includes**
  - **Object Model Development Tools (OMDTs)**
    - **automated support to developing HLA OMs in accordance with OMT specifications**
  - **Object Model Library (OML)**
    - **WWW-accessible library of completed OMTs**
  - **Object Model Data Dictionary**
    - **dictionary of commonly used OM data offered for DoD distribution**

- **First public release targeted for Fall 97**
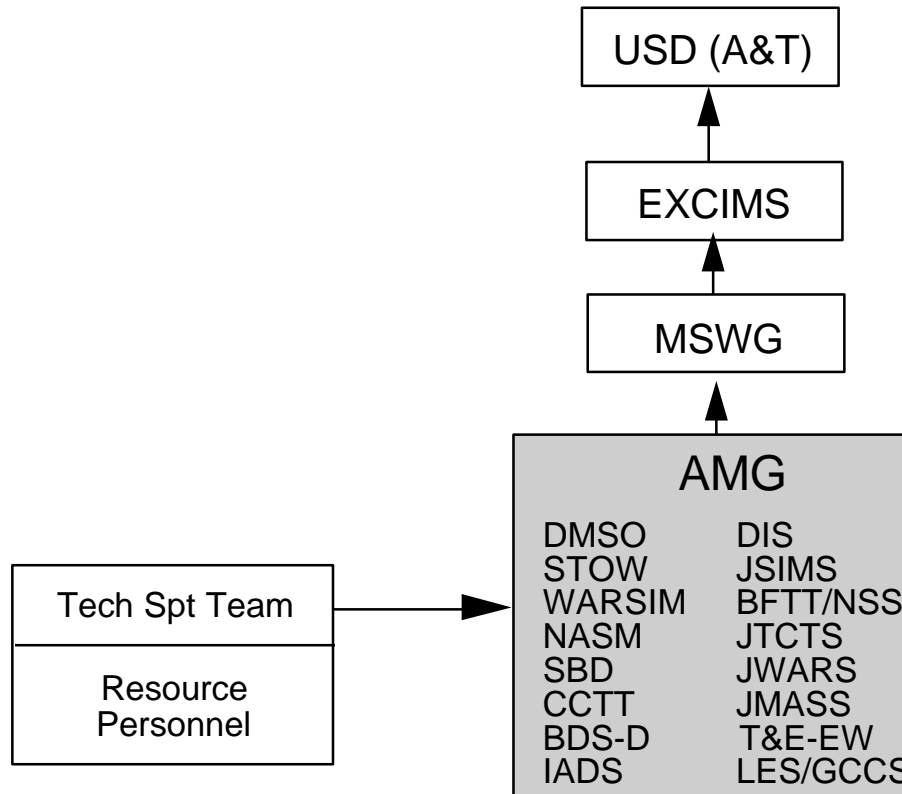 - **To include at least one OMDT and access to the OML**

HLA Development Process Overview

DoD Policy Issued
10 Sept 1996

Industry concepts

Previous DoD architecture efforts

Mar 95

Aug 96

Prototypes

Evolution

Initial definition of HLA

Baseline definition of HLA

Program Evaluation Team

DoD-wide Architecture Management Group

HLA Evolving through an
Integrated Product Team Structure

USD (A&T)

↑

EXCIMS

↑

MSWG

↑

AMG

DMSO	DIS
STOW	JSIMS
WARSIM	BFTT/NSS
NASM	JTCTS
SBD	JWARS
CCTT	JMASS
BDS-D	T&E-EW
IADS	LES/GCCS

Tech Spt Team

Resource Personnel

MSWG
Modeling and Simulation Working Group (0-6)

AMG
Architecture Management Group

Approximately 240 players total:
(Baseline)

	35%	government
	12%	FFRDC
	5%	academia
	48%	industry

Premise for HLA Evolution

- Changes/enhancements should be based on issues raised by users of HLA

- Changes need to be evaluated in terms of benefits and impacts on the HLA user community

- AMG is the focus for evolution including identifying issues, evaluating options for addressing the issues, and approving changes

- As other programs begin implementation of HLA, they will be represented in the AMG process

Five Step HLA Evolution Process

- **Step 1**
  - an AMG member expresses a need for a capability, options for meeting that need, and generality of need areas

- **Step 2**
  - a summary issue paper and investigation plan is developed, and issue team is formed to conduct investigation

- **Step 3**
  - plan is executed, tech exchanges are conducted to review technological progress and issues, with status updates given at AMG meetings

- **Step 4**
  - recommended changes to HLA spec are drafted, integrated across specifications by TST, reviewed by AMG technical community

- **Step 5**
  - AMG reviews recommended changes

TST Support to HLA Evolution Process

- **TST members will be designated as focal points for key areas, they will form the core of the TST, and the TST will be the vehicle for integration across areas; current focal points are:**

    - **Bob Lutz: OM**

    - **Reed Little: IF Spec (API)**

    - **Richard Fujimoto: TM**

    - **Katherine Morse: DDM**

    - **Judith Dahmann: Federation Management (FM)**

    - **Phil Zimmerman: Security**

Regular HLA Checkpoints

- **Six month cycles will serve as routine checkpoints in the HLA process**

- **At least one month prior to each checkpoint**
  - **progress of issue investigations will be checked**
  - **proposed changes in architecture and impact on specification will be evaluated**
  - **draft changes in specifications will be prepared for AMG review**

- **TST focal points are responsible for drafting and integrating changes across the specifications**

- **Checkpoints also provide timing for externally motivated changes in specifications (e.g. text updates, deleting parameters)**
  - **Specs have comment forms; these will be maintained by DMSO and coordinated via the TST**

First Checkpoint was February 1997

HLA Supporting Standards

- **Important that HLA be integrated into broader, industry based technical community**

  - **Many HLA concepts/goals were birthed within DIS/IEEE workshop**

  - **HLA development supports achievement of the DIS Vision**

  - **DIS players are deeply involved in HLA development**

  - **The Simulation Interoperability and Standards Organization (SISO) (successor to the DIS Workshop) is the desired venue for establishment of HLA supporting standards.**

DIS 2.X

SISO Standards

HLA/AMG
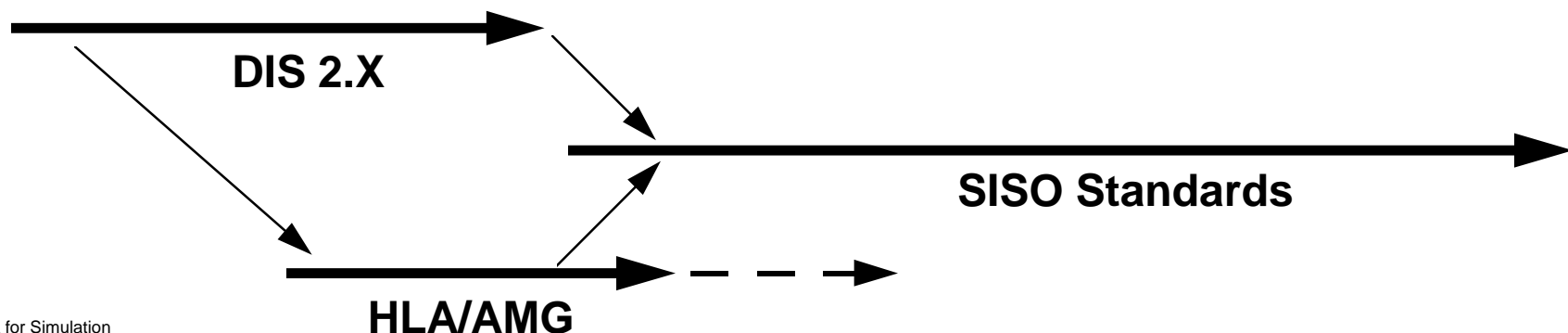
HLA Technical Library

- **DMSO has established an online "public library" for the M&S community, available through the DMSO Web page**

- **Contents**
  - **HLA Baseline Definition (Rules, Interface Specification, Object Model Template)**
  - **HLA Glossary**
  - **Interface Specification Supporting Documents (Test Procedures, Time Management, API)**
  - **OMT Supporting Documents (OMT Extensions, Test Procedures)**
  - **HLA Compliance Checklist**
  - **HLA Federation Development Process Model**
  - **HLA Security Architecture**
  - **Additional briefings and documents**

On-Line Documentation

- **Proceedings and products of the AMG appear under the topic "Architecture Management Group", on the HLA home page site at:**
  - **http://hla.dmso.mil/**

- **Specific questions can be directly addressed to DMSO via electronic mail at**
  - **hla@msis.dmso.mil**

Back-Up Slides

DIS

- **Applies to only real-time, platform level niche of M&S market**

  - **HLA applies to multiple time management schemes**

- **Embedding data in architecture has caused protocols to be inflexible and ineffective**

  - **HLA separates data from architecture; evolve data as required by applications**

- **DIS uses full broadcast distribution approach**

  - **Does not scale from a network or processor viewpoint**
  - **HLA selectively passes data among simulations**

- **HLA is built around simulation services that DIS does not possess**

ALSP

- **Applies to only discrete-event, logical-time niche of M&S market**
  - **HLA applies to multiple time management schemes**

- **Designed to accommodate legacy simulations**
  - **HLA new, more robust approach designed in from onset**

- **Evolution driven by JTC needs**
  - **HLA supports broad DoD user community**

EXCIMS

DDR&E (Chair)

ASD(C^3I)

DUSD(R)

OSD/PA&E

ASD(ES)ICA

DTSE&E

Joint Staff, J-7

Joint Staff, J-8

Army

Navy

Air Force

Marine Corps

Intelligence Community

MSWG

DMSO (Chair)
OUSD (P&R)
ODTSE&E
OASD (C3I)/CISA
OSD/PA&E
ASD (ES)/DASD(IA)
OASD (RA) (RT&M)
Joint Staff, J-6
Joint Staff, J-7
Joint Staff, J-8
HQ DCSOPS DAMO-ZS
OPNAV, N6M
U.S. Air Force
MCMSMO/MCCDC
DARPA
BMDO
NSA
DISA/D-8
DMA
DSWA
JWFC
DMA(TMPO)
AFCCC
NRL
DIA
JSF/MSA

AMG Representatives

Defense Modeling and Simulation Office (Chair)

Distributed Interactive Simulation

Synthetic Theater of War

Joint Simulation System

Warrior Simulation for the Year 2000

Battle Force Tactical Trainer/Naval Simulation System

National Air and Space [Warfare] Model

Joint Tactical Combat Training System

Simulation Based Design

Close Combat Tactical Trainer

Joint Warfare System

Joint Modeling and Simulation System

Test & Evaluation/Electronic Warfare

Integrated Air Defense Simulation

Leading Edge Services/Global Command and Control System

Battlefield Distributed Simulation-Developmental

Joint Advanced Distributed Simulation

Joint National Test Facility

Mobility Analysis Support System

Joint Simulation System-Maritime

Computer Aided Modeling and Equipment Evaluation

Joint Virtual Laboratory

HLA Compliance

- **HLA compliance checklist has been developed**

- **Testing Working Group has defined testing procedures for the interface specification and the OMT. These guide HLA compliance testing.**

- **By June FY97, Services must bin simulations into three categories:**
  - **HLA-compliance actions initiated immediately**
  - **HLA-compliance actions initiated at a specific future date**
  - **no HLA-compliance planned (thus requiring eventual retirement or a waiver**

- **Timetable for Implementation**
  - **FY99: no more development of non-compliant simulations**
  - **FY01: no more use of non-compliant simulations**